RESEARCH HIGHLIGHT

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ASSESSING THE IMPACT OF THICKNESS ON THE PERFORMANCE OF STUCCO CLADDING

INTRODUCTION

The use of two-coat stucco cladding has been a common practice in the Alberta residential building industry. However, the practice does not generally meet the thickness requirement of 19 mm specified in the Alberta Building Code, which reflects the historical use of a three-coat stucco system.

This research was undertaken on behalf of the Alberta Housing Industry Technical Committee through Canada Mortgage and Housing Corporation (CMHC) and the Alberta Home Builders' Association, to determine if the current two-coat practice achieves the same performance as the Alberta Building Code three-coat stucco cladding. This work was being done to explore the feasibility of requesting a reduction in the two-coat method from 19 mm to 15 mm in the Alberta Building Code.

RESEARCH PROGRAM

Identifying applicable standards

The research program was divided into four phases. The purpose of the first phase was to identify relevant properties of stucco cladding and determine appropriate test methods to measure these properties. Water management and serviceability were identified as the major performance benchmarks that should be used to evaluate stucco cladding performance. In general, no standard test methods were found to evaluate stucco cladding. Test methods documented in ASTM C1185 could be used to measure some of these properties; however, no testing agency in Canada was certified to perform these measurements.

Laboratory testing

Laboratory testing was the second phase of the research. Two vertical test panels each 1,200 mm x 2,400 mm were constructed of 38 mm x 140 mm wood studs at 400 mm centres. A full sheet of OSB sheathing was fastened to the face of the studs. Table 1 shows the construction of the test specimens. While some checking was observed in the scratch coat of both specimens before applying the other coats, the researchers did not observe any checking in the finish coat of either specimen.

Table 1: Characteristics of stucco test specimens

Specimen number	J-trim thickness	Nominal stucco	Number of coats thickness	Lath	Sheathing paper
1	19 mm	21 mm	3	50 mm welded wire	30-minute 1 layer
2	15 mm	15 mm	2	50 mm welded wire	30-minute 1 layer

Note: The stucco specimens measured several mm thicker than their nominal dimensions.

The stucco test specimens remained in the lab for about two months. Then, four 600 mm x 600 mm samples were cut from the panels to be used in the laboratory testing. In addition to the panels, six 150 mm diameter and one 300 mm x 900 mm specimen, all nominally 25 mm thick, were cast from both the scratch-coat paste and the finish-coat paste while the panels were being made.

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The National Research Council (NRC) measured the water management properties of water vapour permeability and liquid diffusivity—a measure of the capacity of liquid water to diffuse within a material. Water vapour permeability was measured according to standard practice and liquid diffusivity was measured according to a method developed at NRC.

Carleton University undertook to measure the serviceability properties of modulus of rupture, elastic modulus and flexural strength. Twenty-four specimens were evaluated, each either 60 mm or 80 mm wide by 300 mm long. The test used was a modified form of a standard procedure that involves testing the specimens in three-point bending over a span of 250 mm and measuring vertical deflection upon application of a load.

Field investigation

The third phase of the project involved field sampling of stucco. A survey instrument was designed to direct the visual survey of stucco cladding. The survey instrument included observable water management and serviceability conditions, outlined in Table 2, and a five-point distress rating system based on the observable conditions, outlined in Table 3.

Table 2: Observable conditions

Water Management	Serviceability
Staining	Cracks
Efflorescence	Material loss
Fungi/algae	Impact damage
Erosion	Accessories
Freeze–thaw	Repairs
Moisture content (measured)	

Table 3: Distress ratings

Rating	Description
Excellent	Functioning as intended, no deterioration
Good	Functioning as intended, normal deterioration
Fair	Functioning as intended, minor distress
Poor	Not functioning as intended, significant deterioration
Defective	Not functioning as intended, needs immediate repair

Mixture effect

The intent of the fourth phase of the project was to conduct a series of tests on variations of stucco mixture to obtain quantitative data on the impact of these variations on the identified performance factors. This phase of the work was not completed.

RESULTS

Laboratory testing

The water management properties of the two-coat and three-coat stucco samples, both water vapour permeance and liquid diffusivity, were found to be similar. The water vapour permeabilities of the cast samples of the finish and scratch-coat paste were measured separately and found to have values similar to that of the stucco specimens, and to general reference values for aerated concrete and mortar.

Therefore, it was concluded that both two- and three-coat systems would provide equivalent performance. However, the liquid diffusivity indicates that, while the factor of safety may be marginally better with thicker stucco, the time to saturation is such that neither system can be expected to provide water management protection under all circumstances. Both two- and three-coat systems will saturate within a few hours to a day if one face is in continuous contact with water.

Based on the serviceability properties measured, as defined by modulus of rupture, elastic modulus and ultimate strength, walls clad with two-coat and three-coat stucco could be expected to have somewhat different serviceability performance. All specimens cracked on application of either the first, second or third load increment, with 75 per cent of the two-coat specimens cracking on application of the first load increment. The research found that the three-coat stucco has a higher ultimate strength than two-coat stucco. Most of the two-coat stucco samples fractured prematurely, perhaps due to the drying cracks present in the scratch coat. With three-coat stucco, it can be speculated that applying the brown coat likely mended some of the cracks in the scratch coat, thus making it strong enough to survive the application of the initial load increments. However, the properties of two-coat and three-coat stucco should be compared with caution because of the limited number of specimens that survived the application of the first load increment.

Field investigation

The field sample consisted of a total of 184 facades on 47 buildings—23 in Edmonton and 24 in Calgary. Most buildings were 3 to 15 years old, with 60 per cent in the 5 to 10-year range. Unfortunately, sufficient buildings of the required age with three-coat stucco could not be found. Only 6 of the sampled buildings had three-coat stucco, while 41 had two-coat stucco. Therefore, a meaningful performance comparison to two-coat stucco could not be made.

The performance of the stucco cladding on each wall was rated as the lowest of the observable conditions, as shown in Table 2 for water management, serviceability, and an overall rating based on the lower of the two ratings. No correlation was found between either water management performance or serviceability with respect to age, orientation, thickness or number of coats. Few of the facades were found to meet the thickness requirements of the Alberta Building Code, with most having less than the proposed 15 mm thickness. There were insufficient samples to provide an opinion as to whether "thin" (15 mm) two-coat stucco cladding would provide performance equivalent to that of three-coat stucco cladding.

However, since approximately half of the two-coat applications were at least 15 mm thick, and most were rated no better than fair, there is concern that the proposed two-coat stucco will not provide adequate performance. Damage was often located at flashing locations, window and door perimeters, and corners, and many of the core samples crumbled when removed, both of which indicate a lack of quality control during application.

Table 4: Summary of observable conditions

Water management rating	Three-coat stucco		Two-coat stucco	
	Edmonton	Calgary	Edmonton	Calgary
Excellent	6	11	17	30
Good	3	1	32	33
Fair	2		29	10
Poor			2	4
Defective				4
Serviceability rating	**Three-coat stucco**		**Two-coat stucco**	
	Edmonton	**Calgary**	**Edmonton**	**Calgary**
Excellent				1
Good	4	11	25	42
Fair	7	1	52	24
Poor			2	7
Defective			1	7
Overall rating	**Three-coat stucco**		**Two-coat stucco**	
	Edmonton	**Calgary**	**Edmonton**	**Calgary**
Excellent				1
Good	4	11	25	42
Fair	7	1	52	24
Poor			2	7
Defective			1	7

IMPLICATIONS FOR THE HOUSING INDUSTRY

The drying ability of a wall system is a function of climate and the balance between wetting (by rainwater) and drying (by evaporation) and is time-dependent. In this regard, stucco can be expected to behave better in a dry, continental climate such as Alberta's than in a damp, maritime climate such as Vancouver's. For that reason, it was proposed to change the code-required minimum stucco thickness to 15 mm in the Alberta Building Code.

While the research was intended to prove that two-coat stucco can match the expected performance of three-coat stucco, the results were largely inconclusive due in part to the lack of an adequate number of samples. The research was also hampered because there are no standard test procedures for evaluating the water management and serviceability of stucco cladding.

Another limitation of the study is that the evaluation of water management performance assumed that there were no cracks or other defects in the cladding or building envelope system. Experience with the construction of the stucco test specimens and the field sampling underscore that stucco is a cementitious material that must be installed and must cure properly if drying cracks are to be avoided. Therefore, cracking must be considered in evaluating water management performance.

In terms of serviceability performance, it is expected that the two-coat stucco provides equivalent performance to three-coat stucco if the service load is below the cracking load; thus, rendering inconsequential the reduction in serviceability performance of two-coat stucco.

However, unless appropriate installation techniques are used to minimize drying cracks, three-coat stucco may provide a margin of safety over two-coat stucco because thinner coats of stucco are inherently less prone to checking and the brown coat can provide some healing of checks in the scratch coat.

The expectations for serviceability performance were limited to the effects of thickness of the stucco, but the serviceability performance of stucco cladding is also dependent on the building envelope system, especially the backup wall. For example, a capillary break should be installed on the interior of stucco to prevent water that is sucked through from moving to the interior of the wall. Changes to mix, base coat thickness, or curing will also have effects. However, the investigation of these factors on performance was beyond the scope of this study.

On reviewing the conclusions of the research, the Alberta home building industry decided against proposing a reduction in the Alberta Building Code-prescribed two-coat stucco thickness from 19 mm to 15 mm. Instead, the industry is, for the foreseeable future, focusing its efforts on educating builders and stucco applicators in best practices, on improving stucco materials and on external building envelope construction practices in general.

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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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